F

P R O T O C O L

of the Third Session of the Joint US-USSR
Working Group on Electrometallurgy

I. INTRODUCTION

1. This session of the Joint US-USSR Working Group on Electrometallurgy took place in the USSR from June 2-13, 1975. The specific meeting places, dates, itinerary, etc. are given in Appendix 1.

The Agenda was as follows:

a. Reports by the chairmen of the Task Forces on the work done in their specific fields of electrometallurgy on agreed subjects of the program from May 1974 to May 1975;

b. Discussion, definition and signing of a joint program of work on the subject: "Joining of Materials in the Solid State", approved by the Joint Commission at their meeting in November, 1974;

c. Brief presentation of new problems for further cooperative work in electrometallurgy;

d. Other questions that might arise.

2. The composition of the USSR working group is given in Appendix 2, and the composition of the US working group is given in Appendix 3.

3. In Moscow, on June 2 and 3, the two groups reviewed the progress in carrying out the joint work to date. Reports were made on the following original subjects of the program:

ELECTROMETALLURGY

- Electron beam evaporation of metallic and non-metallic materials in vacuum (by Messrs. Movchan and Bunshah);

- Electro-slag technology (by Messrs. Emelyanenko and Flemings);

- Plasma arc melting of metallic materials (by Messrs. Grigorenko and Wasilewski);

- Research and development of general and special purpose welding materials (by Messrs. Pokhodnya and Savage).

Also discussed in general terms were the two new topics previously agreed upon and approved, namely, cryogenic testing of materials (by Messrs. Yushchenko and Van Echo) and Joining of Materials in the Solid State (by Messrs. Kashin and Heckel). These two topics were discussed in detail at later meetings of the principal investigators during the various visits, and the conclusions are given elsewhere in this Protocol.

A discussion took place on the subject of possibly expanding cooperation and adding new topics to the program of cooperation. Both sides recognized that the present program would have to be essentially completed before expanding it further, but proposals for expansion must begin soon (see "Conclusions and Agreements" below).

4. During the period of June 4 to 12 the United States delegation visited industrial establishments, laboratories of scientific-research institutes and institutions of higher education for more detailed discussion of their cooperation and a study of their accomplishments in the field of electrometallurgy (see Appendix 1). The Working Groups met again in Moscow on June 13 to discuss and finalize

agreements on a series of problems and details of the program of work.

5. Both sides noted the deep mutual interest existing in the discussion of, and agreements on, all the subjects and the absence of significant differences of opinion, as well as the mutual cooperation in arriving at conclusions and agreements.

II. CONCLUSIONS AND AGREEMENTS ON THE COOPERATIVE TECHNICAL WORK

(Note: In the following paragraphs, the numbers refer to the detailed items listed in the Appendices of the Second Protocol.)

A. Both sides took note of the following status of work completion in reviewing the cooperative work done:

Electron-beam evaporation of metallic and non-metallic materials in vacuum. Work on Part I of the subject is progressing in a satisfactory manner. The Soviet side has provided samples of condensates. The U.S. side will provide similar samples in October - November, 1975, during the Soviet visit to the U.S. A further exchange of samples will take place in 1975-1976.

Work under Part II is currently being delayed due to the absence of an agreed method of tool evaluation and a plan for the exchange of coated cutting tool bits. A plan is now under discussion and details will be arranged during the Soviet visit to the U.S. in October-November, 1975. It would

be helpful if both sides exchanged proposals on methods of research on tool evaluation (for hard metal cutting tools) before September 1, 1975.

Also necessary is the additional clarification of the plan and time periods for carrying out Part III by Airco-Temescal.

Plasma arc melting of metallic materials. (Note: G.M. Grigorenko has replaced V.T. Lakomski as the Soviet responsible person.) It was noted that by June 1, 1975 the U.S. and the Soviet sides had accomplished the following:

Part I

Point 1 (a) The Paton Institute and Stanford University have initiated work on the solubility of nitrogen in iron-carbon and iron-oxygen systems.

Point 1 (b) The Paton Institute, the University of Michigan and Stanford University have prepared alloys and have started accumulating experimental data on the solubility of nitrogen in specific types of steels to check the previously developed methods of calculation.

Point 1 (c) Stanford University has initiated studies of the effect of surface-active elements (oxygen and sulphur) on the speed of solubility and diffusion of nitrogen in liquid metals.

Point 2 (a) The Paton Institute is carrying out research on the interaction between nitrogen in plasma and liquid binary alloys of iron with copper and silicon.

Iron-nickel alloys with carbon have been prepared for this study.

Point 2 (b) The Baikov Institute has prepared experimental test equipment and has initiated studies of the interaction between carbon and oxygen in liquid metals during plasma arc melting.

Point 2 (c) MIT (Professor King) together with the Union Carbide Company (Dr. Reed) have initiated study of the kinetics of interaction of nitrogen with liquid metal.

Point 2 (d) The Baikov Institute has carried out a calculated evaluation of the surface temperature of the bath and has provided the U.S. side with the results. Michigan University has started the development of a mathematical heat transfer model.

Part II

Point 1 The Paton Institute together with "Glavspetzstal" has developed technology of the preparation of steel electrodes with a low nitrogen content for plasma-arc remelting.

Point 2 The Paton Institute and "Glavspetzstal" are doing research on alloying steels with nitrogen in plasma-arc remelting in order to select the optimum parameters. At the agreed time (third quarter of 1975), a 300-500 kg ingot (approximately 0.7 percent N_2) will be forwarded to the U.S. side to fulfill Point 3 of the work plan. The U.S. side will inform the Soviet side of the best port of entry into the U.S.

Point 3 Battelle is preparing to undertake this task on receipt of the ingot from the Soviet side.

Electro-slag technology. In the absence of Professor Medovar, the Soviet responsible person, the main discussions were held with Dr. Yu. G. Emelyanenko.

In accordance with the program of joint work on electro-slag technology, both sides agreed to conduct the necessary work aimed at creation of a mathematical model of the electro-slag process.

Part I

Work on Part I is in progress on both sides and it is agreed that a joint Task Force meeting will be held in the U.S. in October-November, 1975, to review that work, to agree on procedures for cooperation and to estimate the time at which the work will be completed.

Part II

As regards Part II, Points 1, 2 and 3, the two sides have clarified the direction of the work to be done and confirmed the target time period in which the investigation is to be completed. Both sides have noted that it is essential to obtain extensive and reliable experimental data on the process of formation of segregates, and also associated thermophysical data, in order to develop the desired mathematical model. Within the period of two months, the Soviet side will provide the U.S. side with the initial data concerning investigations of the formation of segregations in electro-slag ingots. The U.S. side will, within the same two months, provide the Soviet side information on the modeling methods and of investigations of the segregation processes in ESR ingots. Further detailed discussions are planned on this subject at the joint Task Force meeting in October-November, 1975.

Part III

The two sides have arrived at the single opinion that the subject of Part III can be dealt with only after work on Parts I and II has been completed.

Research and development of general and special purpose welding materials.

Part I

The Soviet side transmitted and the U.S. side received, on the day of departure of the U.S. delegation from the U.S., proposals for the exchange of welding and base materials for research purposes. The U.S. side has established working relationships with the following firms: Chemetron, Hobart, Union Carbide, Airco and McKay and has obtained their permission to provide welding materials to the USSR and their willingness to participate in the program of experimentation. On the Soviet side, because of licensing agreements, the Soviets have requested permission from Chemetron to furnish the U.S. two types of flux-cored welding wire. The U.S. side will inform the Paton Instutute prior to August 1, 1975 of the materials and samples to be transmitted to the USSR and the estimated date of transmittal. The two sides will at the same time exchange information on the testing procedures to be used in testing the materials which they received.

The Paton Institute will, prior to the dates as agreed in Appendix 4, transmit to the RPI steel samples and welding materials for the experiments.

The Soviet side informed the U.S. side that, in 1974, the Paton Institute and Union Carbide exchanged representative welding materials. The Soviet side transmitted to that firm flux-cored wires of types IIII-AH4 and IIII-AH8 for welding in carbon dioxide gas and also both fused and ceramic fluxes.

Receipt is acknowledged on the U.S. side of fluxes "Linde-60" and "Linde-80", a ceramic flux and type C-707 flux-cored wire for welding in carbon dioxide gas. The testing of these welding materials will be completed in 1975 by both sides.

Part II

The Paton Institute has prepared the following programs of experiments:

(a) Development of experimental procedures for methods of predicting the hydrogen content in weldments made with type E-7018 electrodes. (see Appendix 4a).

(b) The development of experimental techniques for methods of predicting low temperature characteristics of weldments with an austenite structure, as given in Appendix 4b.

These programs and plans have been transmitted to the U.S. side, for submittal to four potential researchers from the U.S. side for a determination of their interest in performing the work. The USSR will be informed of the names of the potential researchers prior to August 1, 1975.

The Paton Institute, during 1974-75, finished work on the subject: "Development of an experimental calculation method for predicting the amount of porosity in weldments made with type E-7014 electrodes".

Part III

The U.S. and Soviet sides have initiated research of low temperature properties of construction materials.

Both sides determined the scope of research, the types of steels and alloys and agreed on basic low temperature tests.

In connection with the interest shown by such firms as Alcoa, International Nickel Company and Armco Steel to participate in carrying out the tests, both sides agreed to clarify Part III. This has been done and the details are given in Appendix 5 of this Protocol.

Prior to October 1, 1975, both sides will exchange the amount of materials necessary to carry out the experiments.

Joining of materials in the solid state. Both sides agreed on a program of work in this field (Appendix 6). This Appendix lists the subjects and work stages, the organizations and individuals being considered for carrying out the work on both sides, the time period assigned to the separate work stages, the target dates of the start and end of the various stages and the manner and forms in which their completion will be reported. The target period allotted for this work is 1975-1977.

III. NEW PROPOSALS

1. The U.S. side proposed the following additional subjects for joint study: "Analysis and development of test methods de-

signed to improve the service properties of ferritic steels and welded joints at elevated temperatures (ca.450° C)".

It was agreed that the U.S. side, by August 15, 1975, will present a program on this subject for consideration by the Soviet side.

2. The sides agreed to exchange, prior to August 15, 1975, proposals for new subjects for a further widening of cooperation in the field of electrometallurgy.

3. Some discussion was held with respect to including work on shaped ESR castings; for example, such products as large valve bodies for power plants. This possibility will be explored further by both sides for inclusion as stated in the previous paragraph.

4. The sides agreed that new projects agreed upon by both sides are subject to approval by the Joint US-USSR Commission. It was also agreed that the expansion of the program should be carried out as a function of the work achieved in the present program.

IV. EXCHANGE OF VISITS, SPECIALISTS AND SEMINARS FOR SELECTED PARTS OF THE PROGRAM

In accordance with the existing agreement to effect periodic exchanges of groups of specialists who would view the conduct of work, or accomplish it, as appropriate, at its various stages and discuss the results achieved, as well as for an exchange of information, the U.S. side agreed to examine the possibility of receiving in the U.S. the following:

(a) A group of four to five specialists for a period of 15 days in October-November, 1975, on the subject of:

"Plasma arc Melting of Metallic Materials". The group would acquaint itself with methods, with equipment and with results of research conducted by the following organizations:

- M.I.T. in Cambridge, Massachusetts;
- Union Carbide in Tarrytown, New York;
- Battelle in Columbus, Ohio;
- Michigan University in Ann Arbor, Michigan;
- Stanford University in Palo Alto, California.

(b) A group of Soviet specialists on electron-beam evaporation and condensation, consisting of four persons, up to 15 days, during the October-November period, at the Oregon Graduate Center, UCLA, Manlabs and Airco-Temescal. The objectives of their vists would be to develop a single method of testing coated cutting tool bits and to agree on arrangements for the order of exchange and testing of the cutting tools and for the balance of the program.

(c) Two specialists from the Paton Institute for a period of up to two months in the fourth quarter of 1975, for carrying out research (in accordance with Parts I and II of the subject) in the RPI and at Lehigh University. The problem of carrying out the work at ITTRI and at the Hobart and Airco firms will be explored by the U.S. side, and, before July 1, 1975, the Paton Institute will be informed of the results in this connection.

(d) With the object of clarifying and defining further details on the subject of "Electro-slag Technology", the sides agreed on a meeting of three-four specialists in October-November, 1975, at M.I.T., and other locations to be agreed upon.

(e) As regards Part III, in the fourth quarter of 1975, three specialists from the Paton Institute, at Lehigh University, Armco, National Bureau of Standards and Alcoa, for a discussion of research methods in the conduct of low termperature tests.

The Soviet side agreed to examine the possibility of receiving in the USSR the following:

(a) A group of up to five U.S. investigators in September-October, 1975, for a period of one week on the subject: "Joining of Materials in the Solid State".

(b) A group of four to five specialists in the fourth quarter of 1975, in Kiev for a period of one to two weeks in the field of welding and welding materials.

(c) A possible meeting in the USSR of U.S. specialists in the field of electro-slag technology, to be decided after the October-November meeting in the U.S.

The dates and places of the visits and the composition of the above delegations will be arranged by correspondence between the appropriate Task Force chairmen and responsible persons.

It was agreed that, at appropriate stages in the implementation of the work, limited seminars would be held in both countries on selected topics. The dates, locations and arrangements for these seminars would be decided as progress continues in the various parts of the program.

It was also agreed that in 1976-1977 a symposium would be held in Kiev in the Paton Institute to cover the work done and the results obtained.

Both sides agreed to hold the fourth meeting of the Joint US-USSR Working Group on Electrometallurgy during the period of May 15 to June 15, 1976 in Washington, D.C., for the purpose of examining the status of work done and to outline the direction of continued cooperation.

V. COMMUNICATIONS

Both sides have noted the delays in the receipt of correspondence (up to 2 1/2 months). The two sides have agreed to take appropriate measures to speed up the correspondence and transmittal of research materials.

VI. This Protocol has been prepared in the English and Russian languages and signed on June 13, 1975. The texts in both languages are equally authentic.

N. E. Promisel

N.E. Promisel
Chairman
U.S. Side of the Joint
US-USSR Working Group
on Electrometallurgy

S.A. Antonov
Chairman
Soviet side of the Joint
US-USSR Working Group
on Electrometallurgy

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Appendix 1

Itinerary for the visit of the

American delegation to the USSR

June 1, 1975, Sunday

Arrival in Moscow (Rossiya Hotel).

June 2, Monday.

Session of the Joint Working Group in Moscow on the premises of the Committee on Science and Technology.

Evening at the Stanislavsky and Nemirovich-Danchenko Theatre (ballet - Swan lake).

June 3, Tuesday

Continuation of the session of the Working Group.

Visit to Quality Alloy Experimental Plant.

Visit to Metallurgical Institute.

Visit to the Problems Laboratory of the Meat and Dairy Industry Institute.

Visit to workshops and laboratories. Technical discussions.

Departure by train for Kiev.

June 4, Wednesday

Arrival in Kiev. Check into Dnepr Hotel.

Delegation received by the President of the Ukrainian Academy of Sciences, academician B. E. Paton (at the Presidium of the Academy of Sciences of the Uk.SSR).

Visit to the Rigidity Problems Institute of the AS (Academy of Sciences) of the Uk.SSR. (Wasilewski, Heckel).

Visit to the Casting Problems Institute of the AS of the UK.SSR (Flemings, Van Echo).

Technical discussions at the Electric Welding Institute.

June 5, Thursday

Discussions at the Electric Welding Institute.

Visit to the Rigidity Problems Institute (Stout, Van Echo).

Visit to the Kiev City Hospital (Promisel).

Continuation of technical discussions on boat during ride on the Dnepr.

Flight to Odessa. Check-in at Chernoye Morye Hotel.

June 6, Friday

Visit to Odessa Steel-Rolling Plant. Technical discussions with the plant director and in the workshops.

Visit to Odessa Opera Theater (ballet - Gisele).

June 7, Saturday

Sightseeing in Odessa. Visit to Odessa Catacombs.

Continuation of technical discussions with the directors of the Odessa Steel-Rolling Plant during boat trip on Black Sea.

June 8, Sunday

Work on Protocol of Third Session of Working Group.

Free time. Additional sightseeing in Odessa.

Flight to Donetsk. Check into Druzhba Hotel. Promisel and Tatishchev remained in Odessa to work on English text of Protocol.

June 9, Monday

Visit to Special Electrometallurgy Problems Laboratory of the Donetsk Polytechnical Institute. Technical discussions in the laboratory.

Sightseeing in Donetsk.

Flight to Zaporozhye. Check into Zaporozhye Hotel.

Departure of Prof. Flemings by plane to Moscow and then on to U.S.

June 10, Tuesday

Arrival from Odessa of Messrs. Promisel and Tatishchev.

Visit to "Dneprospetsstal'" Plant. Technical discussions with chief plant engineer and in workshops.

Sightseeing in Zaporozhye and environs.

Flight to Leningrad. Check into Leningrad Hotel.

June 11, Wednesday

Sightseeing in Leningrad and environs.

Visit to S. M. Kirov Opera and Ballet theater (ballet - "The Legend of Love").

June 12, Thursday

Visit to the Hermitage.

Visit to the Leningrad Polytechnical Institute.

Departure for Moscow.

June 13, Friday

Arrival in Moscow. Check into Rossiya Hotel.

Continuation of Session of Joint Working Group on premises of Committee on Science and Technology.

Signing of the Protocol of the Third Session.

June 14, Saturday

Sightseeing in Moscow.

June 15, Sunday

Departure for U.S.

Appendix 2

LIST

of members of the Soviet delegation participating in the work of the Third Session of the Joint Soviet-American Working Group on Electrometallurgy

S. P. Antonov	- Division Chief, Committee on Science and Technology, Doctor of Technical Sciences (Head of Delegation)
I. K. Pokhodnya	- Chief Scientist-Secretary, Presidium of the AS of the Uk.S.S.R., Corresponding member of the AS of the Uk.S.S.R.
B. A. Movchan	- Division chief, E. O. Paton Electric Welding Institute, Corresponding Member of the AS of the Uk.S.S.R.
V. I. Kashin	- Deputy Director, Metallurgical Institute, Candidate of Technical Sciences
L. V. Kovalenko	- Chief Specialist, Committee on Science and Technology, Candidate of Technical Sciences
S. N. Glebov	- Expert, Committee on Science and Technology
G. M. Grigorenko	- Senior Scientist, E. O. Paton Electric Welding Institute, Candidate of Technical Sciences
S. A. Fomina	- Senior Engineer, E. O. Paton Electric Welding Institute
Yu. G. Yemelyanenko	- Senior Scientist, E. O. Paton Electric Welding Institute, Candidate of Technical Sciences
M. Kh. Shorshorov	- Laboratory Chief, Metallurgical Institute, Doctor of Technical Sciences
K. A. Yushchenko	- Senior Scientist, E. O. Paton Electric Welding Institute, Candidate of Technical Sciences

Appendix 3

LIST

of members of the American delegation
participating in the work of the Third
Session of the Joint Soviet-American
Working Group on Electrometallurgy

N. E. Promisel	- Chairman of U.S. Working Group, Formerly Executive Director, National Materials Advisory Board, National Academy of Sciences
R. F. Bunshah	- Professor, University of California at Los Angeles
M. C. Flemings, Jr.	- Professor of Metallurgy and Materials Science, Massachusetts Institute of Technology
R.W. Heckel	- Professor of Metallurgy and Materials Science and Head of Department, Carnegie-Mellon University
W. F. Savage	- Professor and Director of Welding Research, Rensselaer Polytechnic Institute
R. Stout	- Professor, Lehigh University
A. Van Echo	- Deputy Branch Chief, Fuels and Materials, U.S. Atomic Energy Commission
R. J. Wasilewski	- Section Head, Materials Research Laboratories, National Science Foundation

Alexis B. Tatistcheff , Interpreter

Appendix № 4

Description, characteristics, amount and date of delivering steels for carrying out investigations on subject: "Investigation and development of general and special purpose welding materials" delivered by the USSR and the USA

USSR					USA				
Steel grade	Thickness mm	Material state when delivering	Amount, t	Date of delivery	Steel grade	Thickness mm	Material state when delivering	Amount, t	Date of delivery
				PIPE STEELS					
7GIS	14-15	after normalization	1.5	1.10.1975	APJ-5LX65	14-15	with controllable rolling	1.5	1.10.1975
5G2AFD	20	- " -	1.5	1.12.1975	APJ-5LX65	20	after normalization	1.5	1.12.1975
7G2A	16.5	- " -	1.5	1.10.1975	APJ-5LX70	16.5	- " -	1.5	1.10.1975
				HIGH-STRENGTH STEELS					
4Kh2GMR	40	quenching with tempering	1.0	1.10.1975	SSS-100	30-40	quenching with tempering	1.0	1.10.1975
2GN2MFAYu	40	- " -	0.75	1.10.1975	T-1	30-40	- " -	0.75	1.10.1975

Note: 1. Pipe steels should be delivered as plates of 1500 x900 mm size. 1500 mm size - along the rolling.

2. High-strength steels are delivered as plates of 1500x500 mm size. 500 mm size - along the rolling.

3. Welding materials should be delivered together with a steel to be welded with these materials.

4. Recommendations on welding - welding conditions, welding speed, preheating and oth., should be supplied simultaneously with materials delivery.

[signature]
[illegible]misel
Chair[illegible]
U.S. [illegible]e of the Joint
US-US[illegible] Working Group
on El[illegible]rometal[illegible]

S.A. Antonov
Chairman
Soviet Side of the Joint
US-USSR Working Group
on Electrometallurgy

Characteristics
of steels being suggested to the American side for exchange 1)

[illegible]	Chemical composition, wt %											Mechanical properties			
	C	Mn	Si	Cr	V	N	Ni	Cu	Mo	S	P	$\sigma_{T0.2}$ kg/mm^2	σ_B, kg/mm^2	δ_5, %	Impact value 2) kgm/cm^2 at −40°C
[illegible]GS[illegible]	0.15–0.20	1.15–1.55	0.4–0.6	≤0.3	–	–	–	–	–	≤0.04	≤0.035	≥40	≥55	≥23	≥4
15G2AFD	0.12–0.18	1.2–1.6	≤0.15	–	0.08–0.18	0.015–0.030	–	0.20–0.40	–	≤0.04	≤0.035	≥40	≥55	≥19	≥4
17G[illegible]F	≤0.20	1.3–1.6	0.3–0.5	–	0.08–0.12	0.015–0.25	–	–	–	≤0.020	≤0.025	≥45	≥60	≥20	≥6
14K[illegible]2GMP	0.10–0.17	0.9–1.2	0.17–0.37	1.4–1.7	–	B 0.002–0.006	≤0.03	–	0.45–0.55	≤0.035	≤0.035	≥60	≥70	≥14	≥4
12G[illegible]2NFAYu	0.09–0.16	0.9–1.3	0.4–0.6	0.5	0.05–0.1	0.02–0.03	1.4–1.7	Al 0.05–0.1	0.15–0.25	≤0.035	≤0.035	≥60	≥70	≥14	≥4

1) By August 1, 1975 the American side will indicate the specific grades of steels, their mechanical properties, manufacturers and chemical composition.

2) Mesnager-notched specimens

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COMPOSITIONS OF WELDING MATERIALS FOR WELDING PIPE AND HIGH-STRENGTH STEELS DELIVERED BY THE USSR AND THE USA

USSR			USA		
Steel grade	Compositions of welding materials	Amount of welding materials	Steel grade	Compositions of welding materials	Amount of welding materials
1	2	3	4	5	6
Pipe steels (longitudinal welds)					
17GIS 17G2AF	Fused flux AN-60 in combination with sv-10G2 wire of 4 mm dia. When using the given composition of welding materials, the impact value at negative temperatures is not guaranteed	Flux AN-60 - 150 kg Wire sv-10G2 of 4 mm dia. - 80 kg	APJ-5LX65	Combination flux + wire (acc. to the suggestion of American side), providing the welded joint on a given steel that would meet the requirements of APJ-5LX standard for main pipeline	Flux - 150 kg Wire - 80 kg
17G2AF 15G2AFD	Agglomerated flux ANK-34 in combination with wire sv-10G2 of 4 mm dia. Impact value of weld metal at $-40^{\circ}C$ is not less than 2.5 kgm/cm^2	Flux ANK-34 - 150 kg Wire sv-10G2 of 4 mm dia. - 80 kg	APJ-5LX70	- " -	Flux - 150 kg Wire - 80 kg

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1	2	3	4	5	6
		Transverse welds – of circumferential type			
17GIS 15G2AFD	Electrodes for welding with the method "downward" of root and hot welds with a cellulose type of the coating x). Electrodes for welding the filling weld with the method "upward" with a basic type of the coating x)	3 mm dia. – 20 kg 4 mm dia. – 40 kg	APJ-5LX65	Electrodes for welding with the method "downward" of root and hot welds with a cellulose type of coating E-8010 x) Electrodes for welding filling weld with the method "upward" with a basic type of coating E-8018 x)	3.25 mm dia. – 20 kg 4 mm dia. – 40 kg
17G2AF	Electrodes for welding root and hot welds with the method "downward" with a basic type of the coating x). Electrodes for welding the filling weld with the method "upward" with a basic type of coating x)	3 mm dia. – 20 kg 4 mm dia. – 40 kg	APJ-5LX70	Electrodes for welding root and hot welds with the method "downward" with a basic type of coating E-8016–E-9016 x) Electrodes for welding filling weld with the method "upward" with a basic type of coating E-8018–E-9018 x)	3.25 mm dia. – 20 kg 4 mm dia. – 40 kg
		High-strength steels			
14Kh21MR	Electrodes ANP -2 of 4 and 5 mm dia. of the E 11018 type	Electrodes ANP -2 4 mm dia – 25 kg 5 mm dia – 50 kg	SSS-100	Electrodes of the E 11018 type. Grade of electrodes is specified by the American side x)	Electrodes 4 mm dia – 25 kg 5 mm dia – 50 kg
12GN2MFAYu	Electrodes ANP -2 of 4 and 5 mm dia of the E 11018 type	Electrodes ANP -2 4 mm dia – 25 kg 5 mm dia – 50 kg	T-1	Electrodes of the E 11018 type. Grade of electrodes is specified by the American side x)	Electrodes 4 mm dia – 25 kg 5 mm dia – 50 kg

x) By August 1, 1975 both sides inform each other the concrete types and grades of electrodes.

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Description, amount and delivery date of the flux-cored wires supplied by the USSR and the USA

Type and application of a flux-cored wire	USSR			USA		
	Wire grade	Amount and wire diameter	Delivery date	Wire grade	Amount and wire diameter	Delivery date 1)
Flux-cored wire of rutile type for CO_2 welding	PP-AN 8	20 kg 2.5 mm	1.10.1975	Dual Shield 7000 "Chemetron Corp."	20 kg 2-2.5 mm	
Flux-cored wire of basic type for CO_2 welding	PP-AN 9	20 kg 2.5 mm	1.10.1975	Fabco 81 "Hobart Brothers"	20 kg 2-2.5 mm	
Self-shielded flux-cored wire for flat welding	The delivery of wire will be clarified after the agreement with "Chemetron Corp."			The delivery of wire will be clarified after the agreement with "Chemetron Corp."		
Self-shielded flux-cored wire for all-position welding	– " –			– " –		

1) Delivery dates are specified by the American side

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P R O P O S A L S

of the Soviet side according to the program of scientific-technical cooperation on subject "Investigations and developments of general and special purpose welding materials"

Section II

"Development of calculated-experimental method for predicting the hydrogen content in weld metal made with the type E 7018 electrodes"

It is suggested to investigate the effect of coating composition (content of CaF_2, $CaCO_3$, SiO_2, MgO), its basicity, nature of deoxidation (various ratio of ferro-silicon and ferro-titanium in the coating), amount of iron powder, humidity of coating on the hydrogen content in deposited metal and to develop the calculated method of predicting the hydrogen content on the basis of experimental data.

The suggested ranges of changing the calculated composition of the coating are given below:

$CaCO_3$	– 25 ÷ 55%
CaF_2	– 5 ÷ 30%
SiO_2	– 10 ÷ 30%
MgO	– 0 ÷ 10%
FeSi	– 2 ÷ 15%
FeTi	– 13 ÷ 0%
FeMn	– 5%

The humidity of coating is changed by cintering the electrodes at temperatures 300°C, 350°C and 400°C.

The additional conditions for compiling the plan of experiment:

$$(CaCO_3 + CaF_2 + SiO_2 + MgO) = 80\ \%$$
$$(FeSi + FeTi) = 15\ \%$$

The investigations are made using the 4 mm dia. electrodes. The coefficient of coating mass is constant and equals ~ 40%, coating thickness is ~ 1.1 mm, $\frac{d_{el.}}{d_{core}} \cong 1.55$.

It is suggested to study the effect of iron powder, its content in the coating being amounted to 0 %; 20 %; 40 %. In introduction of iron powder into the coating the amount of all remaining constituents proportionally decreases.

Welding conditions: welding is carried out with a semi-automatic machine at d.c. of reversed polarity. The welding current value should be equal to ~ 180 A. The voltage is nominal. In determination of hydrogen content in the deposited metal the welding is carried out only with a first half of an electrode.

Determination of hydrogen content in the deposited metal.

a) Method of sampling - in accordance with a methodology, recommended by IIW.

b) Determination of diffusion hydrogen amount is carried out according to the methodology recommended by IIW (in mercury) or by another methodology, providing the trusty results.

c) Determination of the residual hydrogen is carried out by the method of vacuum melting.

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PLAN OF EXPERIMENT

[illegible]gO	CaF_2	SiO_2	Marble	Ferro-silicon	Ferro-titanium	Iron powder	Ferro-manganese	Cintering temperatureC
[illegible]0,0	5,0	I0,0	55,0	I5,0	0	0	5	400
0	30,0	25,0	25,0	I5,0	0	0	5	400
0	I5,0	I0,0	55,0	I5,0	0	0	5	400
0	30,0	I0,0	40,0	I5,0	0	0	5	400
[illegible],0	[illegible],0	30,0	35,0	I5,0	0	0	5	400
[illegible]	25,0	20,0	25,0	I5,0	0	0	5	400
[illegible]0,0	5,0	20,0	45,0	I5,0	0	0	5	400
[illegible],0	I0,0	30,0	30,0	I5,0	0	0	5	400
[illegible]0,0	5,0	I0,0	55,0	2,0	I3,0	0	5	300
0	30,0	25,0	25,0	2,0	I3,0	0	5	300
0	I5,0	I0,0	55,0	2,0	I3,0	0	5	300
0	30	I0,0	40,0	2,0	I3,0	0	5	300
[illegible]0,0	5,0	30,0	35,0	2,0	I3,0	0	5	300
0	25,0	30,0	25,0	2,0	I3,0	0	5	300
[illegible]0,0	5,0	20,0	I5,0	2,0	I3,0	0	5	300
[illegible]0,0	I0,0	30,0	30,0	2,0	I3,0	0	5	300
6,0	3,0	6,0	33,0	9,0	0	40	3	300
0	I8,0	I5,0	I5,0	9,0	0	40	3	300
0	9,0	6,0	33,0	9,0	0	40	3	300
0	I8,0	6,0	24,0	9,0	0	40	3	300
6,0	3,0	I8,0	2I,0	9,0	0	40	3	300
0	I5,0	I8,0	I5,0	9,0	0	40	3	300
6,0	3,0	I2,0	27,0	9,0	0	40	3	300
6,0	6,0	I8,0	I8,0	9,0	0	40	3	300
6,0	3,0	6,0	33,0	I,2	7,8	40	3	400
0	I8,0	I5,0	I5,0	I,2	7,8	40	3	400
0	9,0	6,0	33,0	I,2	7,8	40	3	400
0	I8,0	6,0	24,0	I,2	7,8	40	3	400
6,0	3,0	I8,0	2I,0	I,2	7,8	40	3	400
0	I5,0	I8,0	I5,0	I,2	7,8	40	3	400
6,0	3,0	I2,0	27,0	I,2	7,8	40	3	400
6,0	6,0	I8,0	I8,0	I,2	7,8	40	3	400
0	I4,5	I6,5	33,0	6,8	5,2	20	4	350
8,0	I2,6	I4,4	29,0	6,8	5,2	20	4	350
4,6	4,0	I8,5	36,9	6,8	5,2	20	4	350
3,I	24,0	I2,3	24,6	6,8	5,2	20	4	350
4,5	I5,7	8,0	35,8	6,8	5,2	20	4	350
3,3	II,7	24,0	25,0	6,8	5,2	20	4	350
3,9	I3,6	I5,5	3I,0	I2	0	20	4	350
3,9	I3,6	I5,5	3I,0	I,6	I0,4	20	4	350
4,8	I7,0	I9,4	38,8	8,5	6,5	0	5	350
3,0	I0,2	II,6	23,2	5,I	3,9	40	3	350
3,9	I3,6	I5,5	3I,0	6,0	6	20	4	300
3,9	I3,6	I5,5	3I,0	6,8	5,2	20	4	400
I0,0	30,0	I3,5	26,5	2,0	I3,0	0	5	400
0	5,0	30,0	45,0	I5,0	0	0	5	300
0	5,0	30,0	45,0	2,0	I3,0	0	5	400
I0,0	30,0	I0,0	30,0	I5,0	0	0	5	400
I0,0	30,0	I0,0	30,0	2,0	I3,0	0	5	300
0	3,0	I8,0	27,0	9,0	0	40	3	400
I0,0	30,0	I0,0	30,0	I5,0	0	0	5	300
0	3,0	I3,I	3I,9	I,2	7,8	40	3	300
5,7	I0,5	I0,0	53,8	2,0	I3,0	0	5	400
[illegible],0	I3,0	9,0	3I,0	9,0	0	40	3	400
[illegible]	[illegible]	6,2	33,0	I,2	7,8	40	3	300
I0,0	I7,5	I0,0	42,5	2,0	I3,0	0	5	400
3,9	I3,6	I5,5	3I,0	6,8	5,[illegible]	20	4	350
3,9	I3,6	I5,5	3I,0	6,8	5,2	20	4	350
3,9	I3,6	I5,5	3I,0	6,8	5,2	20	4	350
3,9	I3,6	I5,5	3I,0	6,8	5,2	20	4	350

Appendix 4b

PROGRAM
for
"Prediction of Low Temperature Properties
of High-Alloy Austenitic Welds"

Objective

To establish a mathematical model, based upon published data and some experimental data, relating low temperature service properties to the chemical composition of weld metal and metallurgical processing variables.

Experimental Model

1. A search of the published literature properties of austenitic welds at low temperatures is to be made for the following systems:

   Chromium - nickel
   Chromium - nickel - molybdenum
   Chromium - nickel - manganese
   Chromium - nickel - nitrogen
   Chromium - nickel - molybdenum - tungsten
   Chromium - nickel - molybdenum - aluminium (titanium)

2. Agreement is to be made on a test matrix system for processing on computers.

3. Exchange of information on materials and their properties is to be made.

4. Development of algorithms for programs on statistical modelling is to be made for forecasting weld properties.

5. Statistical processing of data will be made for determination of mathematical relationships of chemical composition (alloying elements) with the mechanical properties and structure of the weld.

6. Develop methods for predictive control of austenitic weldment properties.

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Suggested mass data matrix for statistic processing of test results of austenite welds

No	Steel grade	Thick-ness, mm	Type of welding wire	Welding process				Shielding medium					Heat input	Chemical composition of weld, weight percent										
				MIG	TIG	Sub-arc	with coated ele-ctro-des	Flux type and grade	Ar	He	CO_2	O_2		C	Cr	Ni	Mo	Ti	Al	Fe	Mn	V	W	[illegible]
				1	2	3	4																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

Heat-treatment after welding		Weld structure		Test temperature, °K	Mechanical properties of weld														Source of information
Temperature, °K	Time at temp. Hrs.	Austenite, %	Ferrite, %		σ_y, $\frac{kg}{mm^2}$	σ_t $\frac{kg}{mm^2}$	δ, %	ψ, %	σ_t^N, $\frac{kg}{mm^2}$	Stress concentration factor K_t	$\frac{\sigma_t^N}{\sigma_t}$	$\frac{\sigma_t^N}{\sigma_y}$	K_{Ic}	K_{Ig}	A_V	σ_{-1}	$\frac{K_{Ic}}{\sigma_y}$	$\frac{da}{dN}$	
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45

Suggested mass data matrix for statistic processing of test results of austenitic *base metals*

No	Steel grade	Melting process				Chemical composition, weight %											Heat temperature, °K	Rolling feature		Gauge (plate thickness or rod diameter)
		in open arc furnace	in induction furnace	in vacuum arc furnace	in induction furnace + VAR	C	Cr	Ni	Mo	Ti	Al	Fe	Mn	V	W	N		Time *at Temper, Hrs.*	Temperature of deformation end, °K *final*	
		1	2	3	4															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

Heat treatment		Structure		Test temperature, °K	Mechanical properties														Source of information
Temperature, °K	Time *at Temper, Hrs.*	Austenite, %	Ferrite, %		σ_{ys} kg/mm²	σ_{ts} kg/mm²	δ, %	ψ, %	σ^{n}_{ts} kg/mm²	Stress concentration factor K_t	$\frac{\sigma^{n}_{ts}}{\sigma_{ts}}$	$\frac{\sigma^{n}_{ts}}{\sigma_{ys}}$	K_{1c} kg·mm$^{3/2}$	K_{1g} kg·mm$^{3/2}$	A_u kgm (J)	A_v kgm (J)	σ_{-1} kg/mm²	$\frac{\Delta a}{\Delta N}$ / ΔK_e	
22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41

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Appendix 5

To section III of

"Research and Development of Welding Materials"

according to the US-USSR joint program

Project title:

1. Investigation of properties of structural materials and their welds for LNG storage and transportation.

   Participants: USSR - E.O. Paton Welding Institute,
   Dr. K. Yushchenko and Prof. D. Rabkin

   USA - National Bureau of Standards, Dr. R. Reed
   - Lehigh University, Prof. R. Stout
   - ARMCO Steel, Dr. Bruner
   - ALCOA, Dr. Kelsey
   - International Nickel, Dr. Decker

   Date - 1976, providing both sides receive materials before the end of 1975.

2. Analysis and development of test methods for evaluation of service properties of welds and welded joints resistant to low temperature, with emphasis on fracture toughness.

   Participants: USSR - E. O. Paton Welding Institute,
   Dr. K. Yushchenko, Prof. V. Makhnenko,
   Dr. A. Ishchenko,
   Institute of Problems of Materials
   Strength, Dr. N. Novikov.

   USA - Lehigh University, Prof. R. Stout
   - National Bureau of Standards, Dr. R. Reed

   Date - the first stage - 1976.

   Investigations and tests will be performed by both sides:-

   On materials used in the USSR: chromium-manganese-nitrogen steel OX13AG19

and its weldments, and aluminium-magnetsium alloy AMG-6 and its weldments.

On materials used in the USA: nickel steels with 5% and 9% nickel and their weldments, and aluminium alloy 5083-0 and its weldments.

Exchange of base materials, welding materials and welded joints by October 1975 in quantities given in the attached list.

The work is to be completed by discussion of results and by joint reports in 1976.

In the process of carrying out this work, an exchange of experts who conduct tests in collaborating laboratories will be made by both sides.

Test procedures for conducting the work on "Study of the properties of structural materials and their weldments for LNG storage and transportation"

1. USA side will conduct the tests according to the attached Table.
2. USSR side will conduct the tests on:
   - static tension;
   - sensitivity to stress concentration under static and dynamic loads;
   - C.O.D.;
   - instrumented Charpy-V with analysis of fracture diagram;
   - static bend;
   - compact fracture toughness by static tensile or bend tests;
   - fatigue strength;
   - fractography and structural analysis of fractured surface.
3. The two sides obtain the data on properties vs. temperatures within the range of 300-76°K.

TEST MATRIX: US-USSR JOINT PROGRAM ON MATERIALS FOR LNG STORAGE AND TRANSPORTATION

Properties, Supply of Alloys	Organization: NBS (Reed)	LEHIGH (Stout)	ARMCO (Bruner)	ALCOA (Kelsey)	INCO (Decker)
Tensile		Fe-12Cr-20Mn;Al-8Mg	Fe-12Cr-20Mn: long. trans.;300, 111, 76 K; base and weld	AL-8Mg 300, 76 K; base and weld; smooth and notched	Fe-9Ni: ferritic weld metal (USSR)
Impact		Fe-12Cr-20Mn;Al-8Mg	Fe-12Cr-20Mn: long. trans.;76-300 K; base and weld		Fe-9Ni: ferritic weld metal (USSR)
Dynamic Tear			Fe-12Cr-20Mn: 76-300 K; base	Al-8Mg: 300, 76 K; base and weld	
C. O. D.			Fe-12Cr-20Mn: 76-300 K; base		
R-Curve			Fe-12Cr-20Mn: 76, 103, 123 K; base, HAZ		
Bend		Fe-12Cr-20Mn;Al-8Mg			
Fracture Toughness, Compact tensile		Fe-12Cr-20Mn;Al-8Mg		Al-8Mg: 300, 76 K; base and weld	
Fatigue Crack Growth Rate	Fe-12Cr-20Mn;Al-8Mg: 300, 111, 76 K; base, weld				
Supply of Fe-5Ni, Fe-9Ni			Fe-5Ni, Fe-9Ni: about 2.5 cm thick plate; weldments in lengths 60 cm x 30 cm wide		
Supply of 5083 Al				5083-O Al: 2.5 cm plate; weldments in lengths 90 cm x 60 cm wide	

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LIST

of materials supplied in the USA and the USSR to carry out the works on "Investigation of properties of structural materials and weldments for LNG storage and transportation"

The USSR side supply to the USA (Lehigh University, National Bureau of Standards) the following representing samples of structural materials:

Grade of steel, of alloy	Sample dimensions, mm	Quantity kg	Date of supply
OX13AG19 (base metal)	200x170x550	300÷400	October 1975
OX13AG19 (welded joint, submerged-arc process	20x200x550	200÷250	October 1975
welded joints of USA 5% or 9% Ni steel with lower nickel content in weld metal	25x200x500	200÷250	April 1976
AMg-6 grade aluminium-magnesium alloy containing 6% Mg	20x300x600	300÷400	October 1975
AMg 6 welding wire with zirconium for aluminium welding	1.6 dia.	40÷50	October 1975

The USA side supply to the USSR (E. O. Paton Welding Institute the following representative structural materials:

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Grade of steel, of alloy	Sample dimensions, mm	Quantity	Date of supply
5% Ni steel (quenching + tempering)	25x300x600	400÷500	October 1975
9% Ni steel (quenching + tempering)	25x300x600	400÷500	October 1975
welded joints of both steels	25x300x600	150÷200	October 1975
Inconel wire 625 2	1.2 dia.	50	October 1975
Inconel wire 82	2.0 dia.	100	October 1975
Inconel wire 92	2.0 dia.	100	October 1975
Inconel electrode Welding Electrode	3÷4 dia.	20	October 1975
Flux - Incoflux 4.	-	50	
Aluminium alloy 5083-0	25x600x900	300÷400	October 1975
Welded joints of 5083-0 alloy	25x600x900	300÷400	October 1975
Welding wire of 0-5183 alloyed with cobalt	1.6 dia.	40÷50	October 1975

1 Address of the USSR side: Ukr.SSR, Kiev-5, 69 Gorky st., E.O.Paton Welding Institute

2 The USA side is to forward its address before August 1, 1975.

3, Both sides may correct the grades, size and quantity of the samples supplied up to 1 August.

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PROGRAMME

of the US-USSR scientific-technical collaboration on the theme "Solid State Joining"

N	Themes	Contents	Possible Organizations from US	Possible Organizations from USSR	Term Begin	Term End	Forms of work completion	Forms of collaboration
1	2	3	4	5	6	7	8	9
I.	Diffusion joining	I. State of-the-art review of solid state joining of similar and dis-similar metals and alloys.	W.A. Owczarski Pratt and Whitney Air-craft East Hartford, Conn.	V.I. Kashin, M.Kh. Shorshorov Baikov Institute of Metallurgy AS USSR, Moscow, B.E. Paton, J.B. Malevsky, Paton Welding Institute, A.S. of Ukrainian SSR, Kiev. N.F. Kazakov Diffusion Welding Laboratory, Moscow E.S. Karakozov Metallurgy evening Institute, Moscow.	1975	1977	Tables, Figures, Nomograms, Reports and articles.	I. Inde-pendent in-vestiga-tions of each side.

1	2	3	4	5	6	7	8	9
		2. Development of techniques and methods for intensifying the joining of similar and dissimilar metals and alloys, considering powders and hot isostatic compaction.	A.T. Male Westinghouse Electric Corp. Pittsburgh, Pa.	V.I. Kashin, M.Kh. Shorshorov Baikov Institute of Metallurgy. G.K. Dzneladze Central Institute for Iron and Steel Metallurgy, Moscow. B.E. Paton, S.M. Gurevitch, Paton Welding Institute. V.N. Gridnev, L.N. Larikov Institute for Physic of Metals, A.S. of the Ukrainian SSR, Kiev N. F. Kazakov, Diffusion Welding Laboratory, Moscow. E.S. Karakozov, Metallurgy evening Institute, Moscow.				2. Exchange of experimental [illegible] [illegible] and specimens. 3. Common seminars and meetings for discussion of results.

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1	2	3	4	5	6	7	8	9
II	Composite materials	1. Investigations of the effect of residual stresses on the mechanical behavior of composites.	L.J. Ebert Case Western Reserve University Cleveland, Ohio. R.W. Heckel Carnegie-Mellon University Pittsburgh, Pa.	V.I. Kashin, M.Kh. Shorshorov, L.M. Ustinov, V.V. Belov Baikov Institute of Metallurgy.	1975	1978	As in I. above.	As in I. above.
		2. Application of acoustical emission to the study of deformation and fracture of composites.	R.M. Fisher and G.R. Speich U.S. Steel Corp. Monroeville, Pa.	V.I. Kashin, M.Kh. Shorshorov, O.V. Gusev, Baikov Institute of Metallurgy.				

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